Why Do Research in Zoological Gardens?

By Kurt Benirschke

There is much change in our world these days and much of the change that is taking place so rapidly will severely affect the lives of our children. I am speaking of course primarily of the ravishing of nature, the wholesale destruction of primeval forests. Unbelievable as it may sound, an acre of original forest is cut every minute, day and night — and, of course, despite many promises and some attempts, hardly any new forest is being created. The ever-increasing conversion of woods into farmland and cities is the result of a continuously rising population — 1 million new people every five days — new citizens of the world with anticipation of perhaps an even better life than their parents had, indeed, with the same expectations of a good life that we have. Although population growth is estimated to slow down or even come to a halt in the next century, the growth of populations in many countries continues unchecked. But there is a limit to the riches of Mother Earth, finite quantities of ores, oil, and certainly of forests which, when they are exhausted, will make life on Earth certainly much dearer than what it now is.

The topic of this article though is the loss of wildlife incurred with the deforestation. Others, notably Norman Myers, have eloquently written about the consequences incurred by us when wholesale destruction of tropical forests (the primary target of current exploitation) takes place, what innumerable plant species will be lost. Many of these species are as yet poorly studied and their nutritional, let alone medicinal value, is currently unknown; yet the species are irretrievably lost. I have recently toured the Paraguayan Chaco, a dry, thorny bushland with many unique trees that take centuries to grow (*quebracho, lapacho, palo Santo*) only to witness that these precious trees are used for firewood and fence posts when systematically that huge area is transformed into lucrative *estancias*.

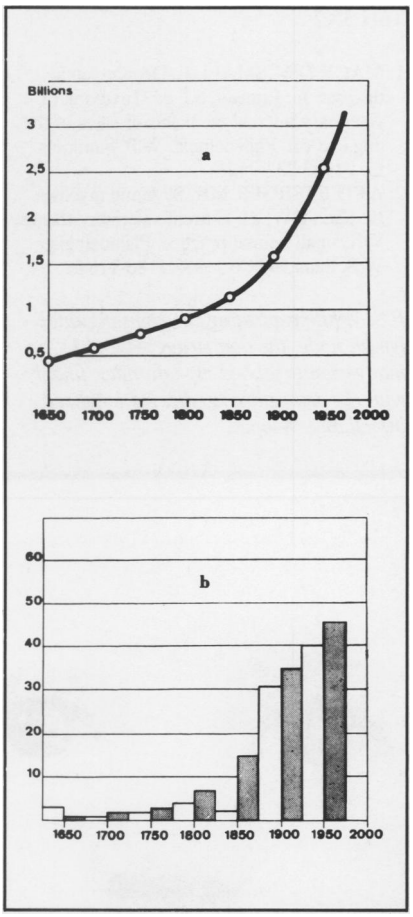

Figure 1. (a) The increase in human population over the last three hundred years. (b) The number of exterminated mammals forms (white bars) and bird forms (black bars) eliminated over the last three hundred years. Each bar represents a 50-year period. From* Extinct and Vanishing Species, *Ziswiler. Springer-Verlag, New York. By permission.

My immediate concern though is the simultaneous extinction of large numbers of animals whose habitat has been eliminated by inundation (for dam construction) or deforestation (to obtain wood or to create farmland). To be sure, hunting, illicit trade of pelts and other animal parts are other significant reasons for the decline of large wild animals (rhinos, elephants, crocodiles, etc.) but much the severest danger to widlife comes from deforestation and incursion by man with roads and habitations into heretofore undisturbed bush and forest. Of course, the process of extinction is not new. It can be witnessed in museums of natural history where the numerous species that roamed Earth before our arrival are exhibited. Good evidence exists, however, that the rate of extinction is markedly increasing, and students such as Ziswiler (Fig. 1) have shown the parallelism of extinction rates of mammals and birds with the expanding human population.

Examples are easy to list. In 1914, the last passenger pigeon died in the Cincinnati Zoo; billions existed in North America when our ancestors arrived. The dodo, the great auk, and many species of lemurs from Madagascar are gone. America's largest bird, the California condor, is down to 28 specimens; rhinos, gazelles, large whales, river dolphins, and big cats are in trouble. The list goes on and on. The smaller species with often regional distribution are less frequently mentioned: the giant otter, small cats, bats, etc.; and few people worry truly about butterflies or snails, but they share a similar fate. Often I am asked why new evolution will not replace those species that have become extinct. The answer is that evolution occurs too slowly to compensate for wholesale extinction, and in all probability we must anticipate a world which will be very much impoverished in its species diversity.

Editor's Note: Dr. Benirschke has been Professor of Pathology and Reproductive Medicine at the University of California, San Diego, since 1970. As Director of Research at the San Diego Zoo from 1975 to 1985, he founded the Department of Research, which is world renowned for its excellence in the application of biomedical technology and modern research methods to the plight of endangered species. The Department is now known as the Center for Reproduction of Endangered Species. This article is based on the Schofield Memorial Lecture given by Dr. Benirschke at the Ontario Veterinary College, October 1986.

Figure 2. The giant Chaco peccary* Catagonus wagneri, *was only discovered in 1972 and is now in peril of extinction. It is confined to the Chaco of Paraguay and Eastern Bolivia and remains virtually unknown biologically as no animals can be exported.

What to do?

In the best of all possible worlds, of course, one would seek a stabilization of the population, employ alternative energy sources, enhance recycling, and foster other measures that seek a reduction of the extinction process. Inasmuch as these targets are partially impractical and expensive, many conservation activists have sought to educate governments and the population in general to create large national parks. These would serve to retain many biota simultaneously and, in the long run, such *in situ* conservation is clearly the best modality presently available.

At the same time, too little is known of many species that are of concern to allow us to make very specific recommendations regarding the size of parks, their location, and the variety of habitats needed; from a particular standpoint, many parks are difficult to patrol or to firmly defend against other land uses, e.g., prospecting for oil. To give a specific example, let me use the tagua. This, the largest peccary, was only discovered in 1972 and it is the last large mammal which has been newly described. Two other species of peccary (white-lipped and collard) are distributed over nearly all of South America, but the tagua (Fig. 2) is confined to the Chaco and is hence called the giant Chaco peccary. The Chaco is a vast area of dry, thorny bush covering the Western half of Paraguay, the East of Bolivia, and a narrow rim of northern Argentina. Why is this unusual animal found only here? What is its lifestyle, its food plants, its general biological character? They are unknown and remain unstudied. But deforestation (conversion into pasture and cropland) proceeds at an alarming pace in this animal's habitat. To be sure, Paraguay has some national parks but whether they contain this species is unknown and the parks are completely unpatrolled at present. So it is possible that the species will become extinct before other than its skeletons are studied. Reasonably reliable information is being gathered to indicate that the tagua is sighted with ever-decreasing frequency by hunters, farmers, and indigenous Indians. Ideally this animal, as so many others, is studied in location. There are, however, either no local scientists to undertake such studies or their support structure is absent. For this and other reasons I have advocated in the past that *ex situ* conservation proceed apace with the creation of national parks.

Ex situ conservationists, largely in the world of zoos, proudly point to the fact that without their efforts the Przewalski's horse, the mhorr gazelle, the milu, and a few other species would have died out. But these successes were either the result of work by staunch individualists or accidental occurrences in the past. More recently zoos have made very deliberate efforts in true conservation. Witness the work with Arabian oryx, rhinoceros, the California condor, to name a few species. Without the joint effort of many zoos, many large animals will surely become extinct. More important to point out, however, is the biological research activity that is going on in zoological gardens. Beginning slowly only a decade ago, research is now a prominent feature of many zoos. This biological research is deemed essential in ascertaining the normal physiology, reproductive biology, genetics, behavior, diseases, etc., of vanishing species. Such research is not only experimental in nature, but is required for the enhancement of reproduction and general health.

At the San Diego Zoo, the research activities have concentrated on genetics, reproductive physiology, virology, behavior, and veterinary aspects. All dead animals are autopsied and much has been learned about causes of death, parasitology, longevity, and comparative anatomy because of the long-standing presence of full-time pathologists. I will briefly give examples of findings in other disciplines to show the necessity of their investigations for conservation.

It is fashionable to discuss the genetics of small populations and the effects of inbreeding. Such considerations have led to numerous, now computerized, studbooks and to inter-zoo population management. Less well appreciated is the need to ascertain cytogenetic parameters. It has been found that chromosome number and structure may vary widely among members of thought-to-be distinct species. Thus Soemmerring's gazelle, dik diks, and numerous species of South American primates differ in their chromosomes, perhaps because they come from locally different subpopulations or because hybridization with other species has taken place in their past captive management. We have advocated that any new breeding program should commence with cytogenetic assessment, particularly in poorly documented species. More esoteric DNA studies are now proceeding for scientific

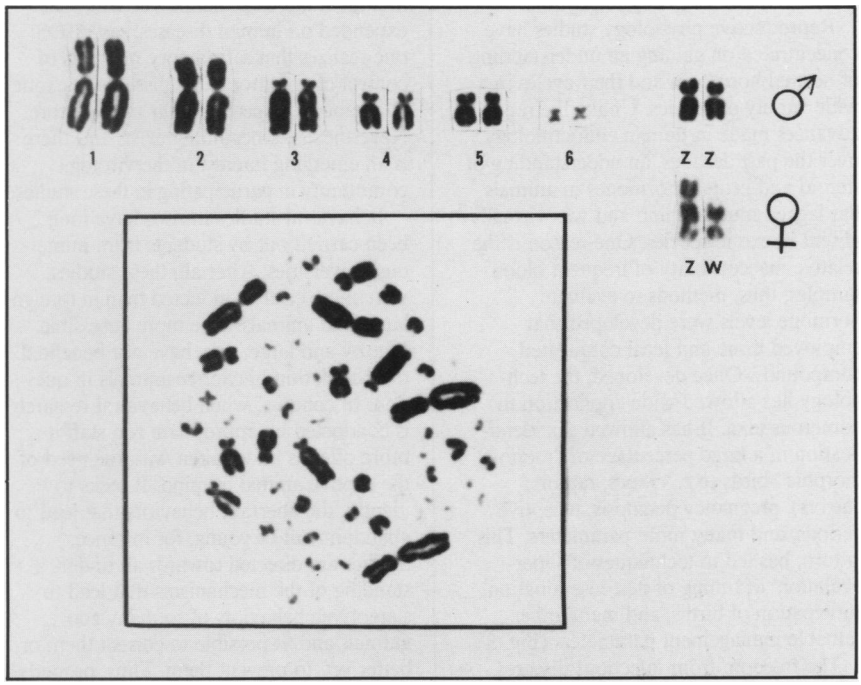

Figure 3. An important tool for management of the California condor is the ability to assign sex accurately in this monomorphic bird. These chromosomes were prepared from lymphocyte culture. In the square a whole cell's chromosomes are shown, the many microchromosomes are difficult to enumerate and are usually ignored. The top row shows the seven pairs of macrochromosomes of a male. The last pair (ZZ) is the fourth largest and its appearance in females (below, ZW) allows unequivocal determination of sex.

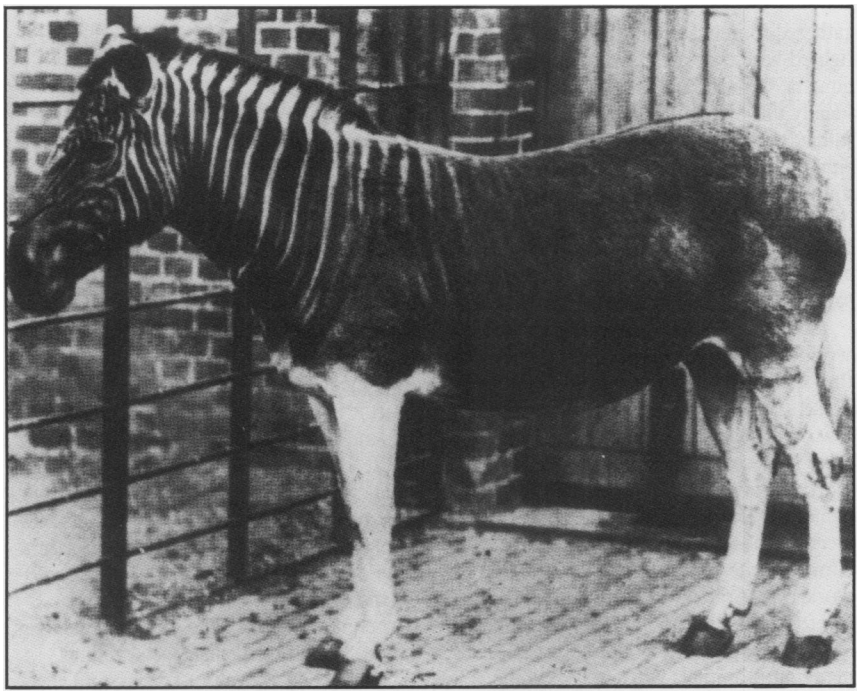

Figure 4. The extinct quagga, a steppe zebra. Photographed in 1870 by Frederick York. Copyright: Zoological Society of London.

reasons and of course by and large, they are possible virtually only from zoo specimens. For this reason "banks" of liquid nitrogen-preserved tissue cultures and autopsy materials have been created, the often misunderstood "frozen zoo". It will not likely serve to reawaken extinct species but it will give our successors the raw materials with which to undertake studies that are currently impossible.

Reproductive physiology studies have concentrated on gaining an understanding of normal hormones and their cycles in a wide variety of species. Unlike the rapid advances made in human endocrinology over the past decades, an understanding of steroid and protein hormones in animals has lagged much behind and was virtually absent in exotic species. One reason is the relative inaccessibility of frequent blood samples; thus, methods to evaluate hormone levels were developed that employed urine and fecal conjugated compounds. Once developed, the technology has allowed wide application to numerous taxa. It has allowed sex identification in a large percentage of "monomorphic" birds (e.g., cranes, raptors, parrots), pregnancy diagnosis, receptive periods, and many more parameters. This, in turn, has led to techniques of superovulation, of timing of best insemination, anticipation of births, and many other valuable management parameters (Fig. 3).

The freedom from infectious diseases, such as smallpox, poliomyelitis, and measles, which modern man enjoys, is the result of determined and detailed laboratory effort to understand these virus-induced diseases. Similar benefits should come to exotic animals if enough effort were expended in the elucidation of viruses, their modes of transmission, vectors, and possible vaccine production. Studies so far have concentrated on diagnostic methods to determine the presence of the herpes virus responsible for malignant catarrhal fever in ungulates and the viral agent of hepatitis that is so widely prevalent in large cats, like snow leopards. When one compares the budget, and the minuscule manpower with that expended on human diseases, say AIDS, one realizes that satisfactory methods of control of common virus diseases in exotic and vanishing species lie far in the future. Nevertheless, a beginning exists and there is an emerging interest in the virologic community in participating in these studies.

Behavioral studies in zoos have long been carried out by students from numerous universities. After all, these studies were more easily conducted than in foreign lands and animals were more accessible. But, by and large, they have not benefited the population of captive animals in question. In contrast, when behavioral research is conducted by appropriate zoo staff it more often is undertaken with the need of the captive animal in mind. It seeks to identify the aberrant behaviors that lead to abandonment of young, for instance. Studies are directed towards an understanding of the mechanisms that lead to stereotypic behaviors of so many zoo animals and, if possible to correct them or, better yet, to prevent them. Thus, properly conducted by competent behaviorists, the design of new cages or exhibits has been influenced to forestall the development of abnormal behvior, and food items have been changed to allow better health. This discipline has much to offer in many other ways and it is of course usually the least invasive and therefore the best tolerated (by staff) scientific endeavor of zoo research.

Veterinary medicine has become a well-established discipline in the zoo world. It not only publishes its own journals, but it has a well-defined training program and specialty boards. Clearly, veterinarians have much to offer in the treatment of ill zoo animals and it goes without saying that broken bones, abscessed teeth, and wounds require medical attention. But the more challenging aspect of zoo veterinary medicine is the prevention of parasitic and other infectious diseases, nutritional determinations, recognition of pregnancy, and many more facets. Few hard data exist so far on the diseases of many wild animals.

These data are gradually being acquired and association meetings, journals, and books begin to correct the dearth of solid information that existed only a decade ago. Several items, it seems to me, require special attention in the future. The first is a better knowledge and appreciation of nutritional needs of the diverse zoo inhabitants. In nature, speciation has established many different niches, including food preferences. Thus, offering only one monkey chow to all or most primates seems ill-advised. Also, feeding practices and type of food offered can do much to reduce the widespread boredom in zoo populations. Then, the rapid advances in diagnostic and therapeutic tools available to physicians (ultrasound, CAT scans, endoscopy, rapid oscillation respiratory therapy, etc.) should more quickly make their way into the armamentarium of the zoo veterinarian. Surely, this is often a matter of economics, but that is not always the case. Here is an area where close collaboration with physicians can be of great benefit. The same applies to the many laboratory resources existing in most human hospitals (radioimmunoassays, cytogenetics, microbiology); they should be brought to bear more often in exotics. I strongly believe in the "One medicine" concept, that few essential differences exist in the diagnosis and therapy of most human diseases and those of animals. Thus, a confluence of these disciplines is highly desirable, and since most zoos exist in larger cities which also contain the teaching hospitals of universities, such cooperation should often be easier to obtain than that which is impeded by the longer distance usually separating veterinary schools from zoos.

Zoo research is emerging as an exciting new discipline. I deem it essential for the maintenance of exotic species in captivity and for *ex situ* conservation.

Additional reading: Vanishing Animals, *by Andy Warhol and Kurt Benirschke. New York, Springer-Verlag, 1986, 112 pages. A portrayal of some of the most endangered animals in the world, from both an artistic and a scientific point of view.*